Seminar for the external evaluation of the preliminary results
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OBSERVATORIO DEL AGUA
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WATER FOOTPRINT AND VIRTUAL WATER TRADE: POLICY IMPLICATIONS

(Guadina Water Footprint)

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Contents

Background

- ‘Virtual water’ coined by Allan (1997, 1999)
  - Conceptually powerful and appealing
  - Empirically untested

- Earlier studies by Chapagain and Hoekstra (2004) and Hoekstra and Hung (2005)
  - Very general quant evaluations
  - Very specific ones (coffee, tomatoes,…)

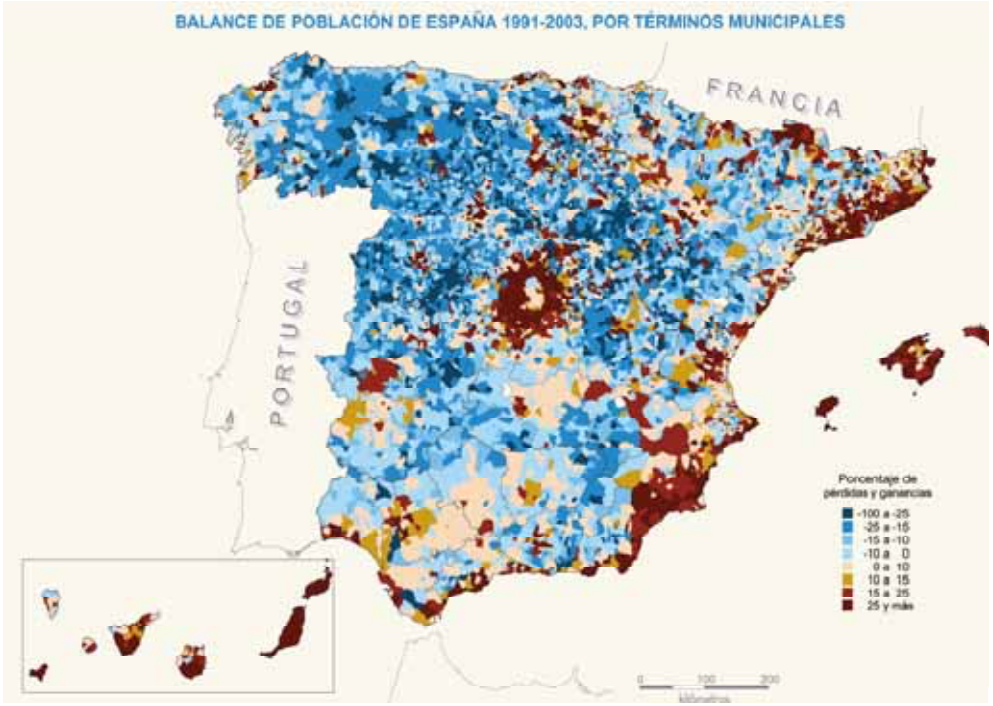
Background
The Case for an application to Spain and the Guadiana

- Spatial and temporal diversity within the Spanish territory
- Very active in farm trade (large importer and exporter)
- Ministry mandates that WF calculations be made for River Basin Management Plans

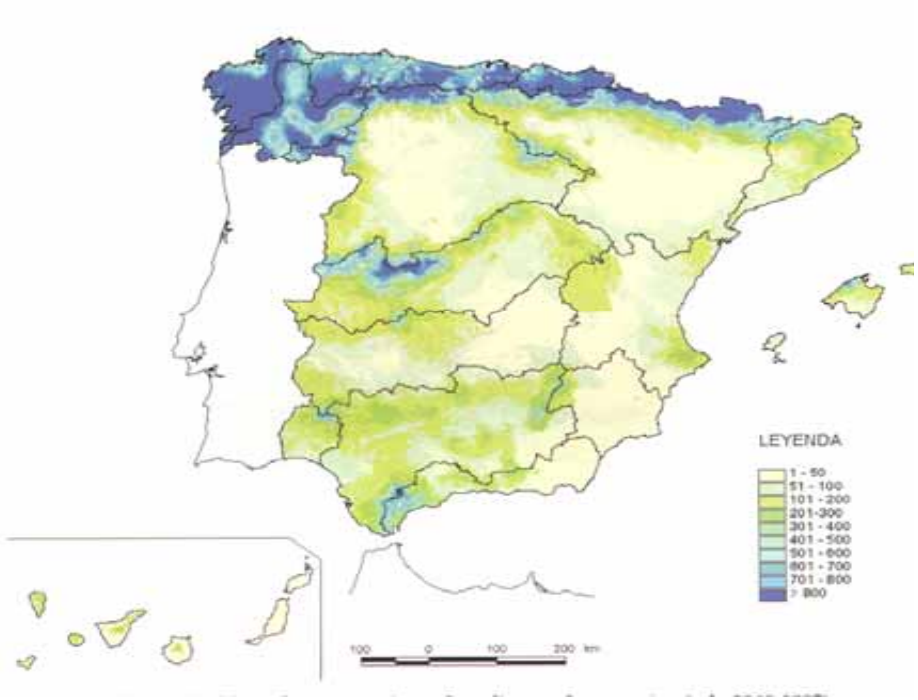
⇒An ideal case study for an in-depth analysis of VW and WF

The Spanish Context

Population change 1993-2001



Annual average Runoff

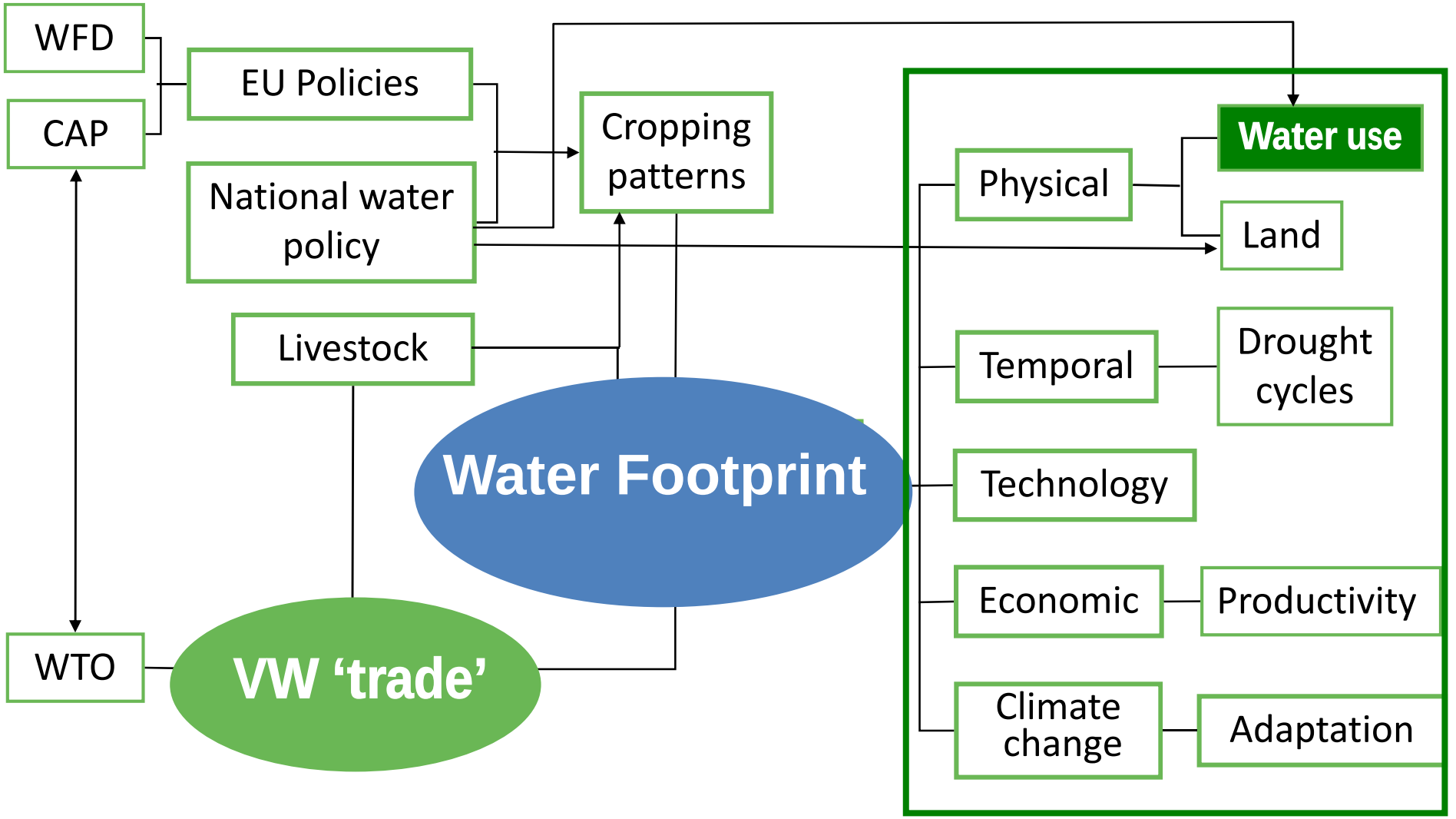


Objectives

1. Evaluate **WF and VW**, considering:
   - Green-blue water components
     - Time and spatial dimensions

2. Add the **economic dimension** to previous studies of WF and VW
3. Evaluate **water scarcity** in light of the evaluations of WF and VW
4. Draw **water and agricultural policies** lessons based on the WF and VW analysis

Conceptual framework (I)



Conceptual framework (II)

- Virtual water (embedded water, embodied water or hidden water)
- The colours of water: green and blue (% vary significantly across time, province and species)
- Virtual water ‘flows’
- Water footprint: Internal and external WF

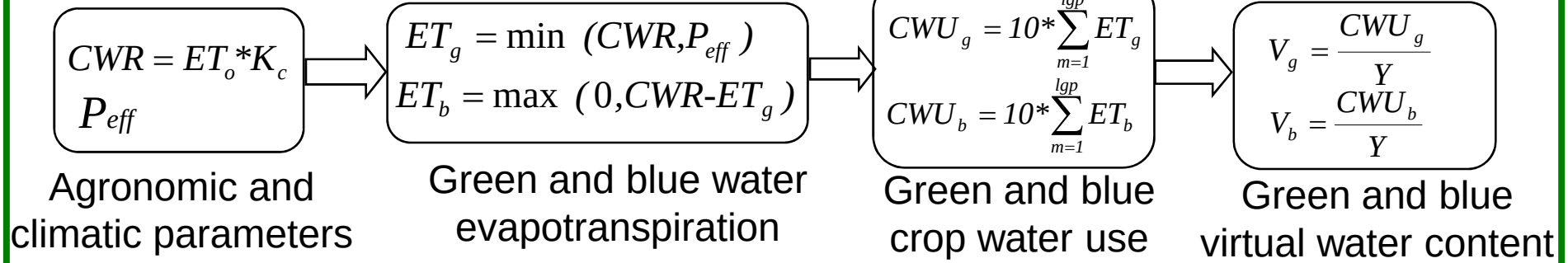
Method (I)

- WF assessed from a top-down approach

$$WF = (WU - VW_E) + (VW_I - VW_{RE})$$

- Agricultural water use (WU_a)

$$WU_a = \sum_{c=1}^{n} \left[CWU_g * S_t + CWU_b * S_{irr} \right] + LWU$$



Peformed for 93 crops 50 provinces and 10 years

Method (II)

- Virtual Water 'Flow'

$$VW[n_e, n_i, j] = V[n_e, j] \times T[n_e, n_i, j]$$

- Water and Land **Apparent** Productivity, economic value of farm output per m^3 and per ha cultivated, respectively

- Economic Value of Water
  - Only blue water is evaluated
  - Shadow price (scarcity value) refers to the marginal value of water (€ per m3, evaluated at basin level and for each year)

Method (III)

- Econometric approach
  - Hypothesis: **water productivity's** dependent on water scarcity and blue-green water %
  - Model (panel / time series data)

$$BWP_{it} = \alpha + \beta_1 SV_{it} + \beta_2 GB\%_{it} + \varepsilon_{it}$$

BWP_{it} inverse of blue water productivity 1000 m^3/€

SV_{it} water scarcity value in €/m^3

$GB\%_{it}$ ratio: green crop water use/total crop water use

Method (IV)

- Exchange terms of virtual water 'trade'

$$ETerms\_VW_t = \frac{VW^t{}_{\exp}(€/m^3)}{VW^t{}_{imp}(€/m^3)}$$

- Macro-economy water dependence

$$Dep\_ratio_t = \frac{VF_t(m^3)}{GNP_t(€)}$$

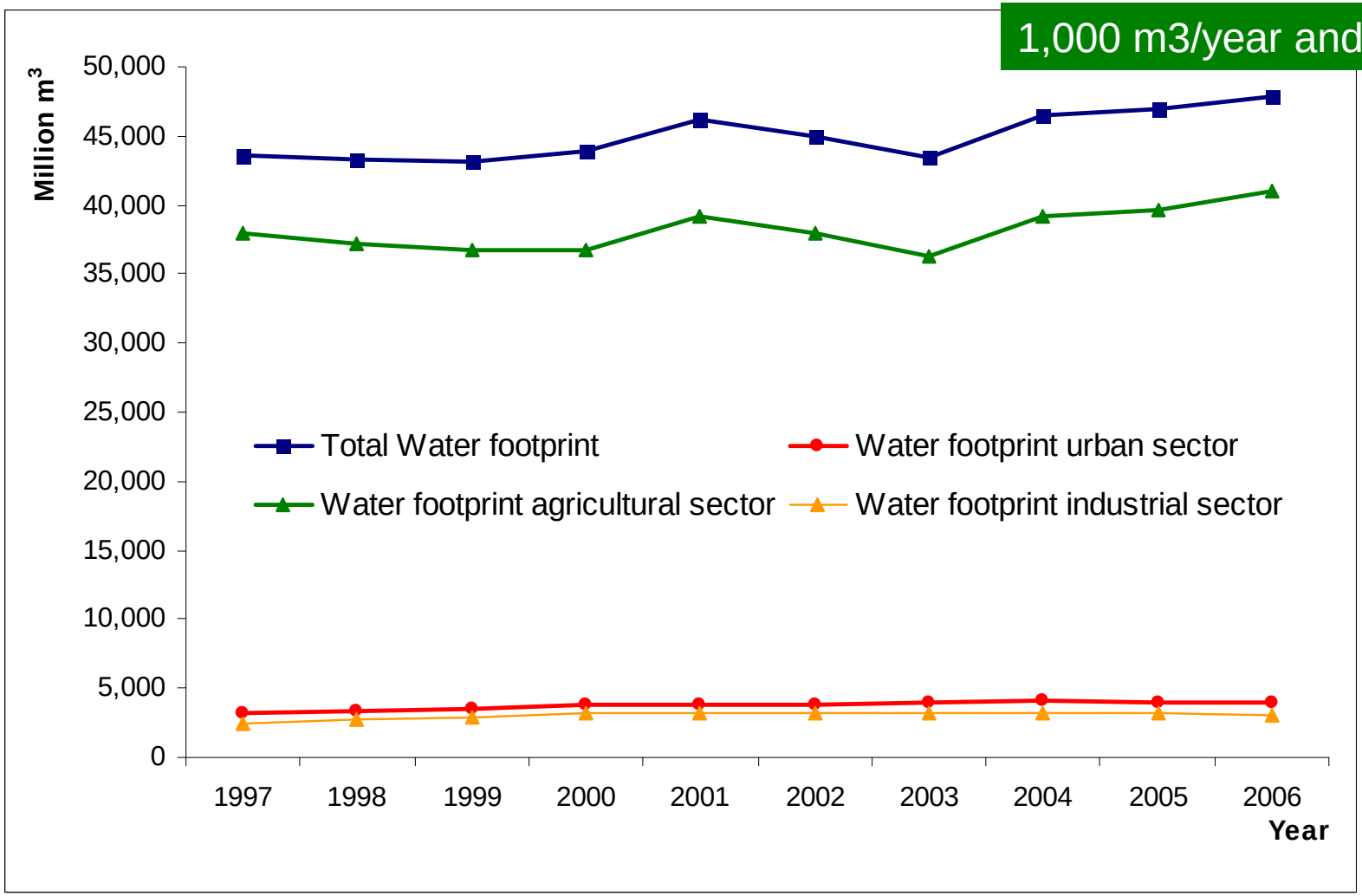
Data sources

Data	Spatial dimension	Time dimension	Source
Climatic	Provincial	1997-2006	Meteorological Agency
Crop area and yield	Provincial	1997-2006	Ministry of Agriculture
Crop parameters	National	-----	Allen *et al.*, 1998
Crop products	Provincial	1997-2006	Ministry of Agriculture
Livestock water use	River basin	2001	Ministry of Environment
Industrial water withdrawal	National	1997-2004	National Statistics Institute
Urban water withdrawal	National	1997-2006	National Statistics Instit.
Trade	Provincial	1997-2006	DataComex
Crop market prices	National	1997-2006	Ministry of Agriculture
Industrial production	Autonomous Community	1997-2006	National Statistics Institute

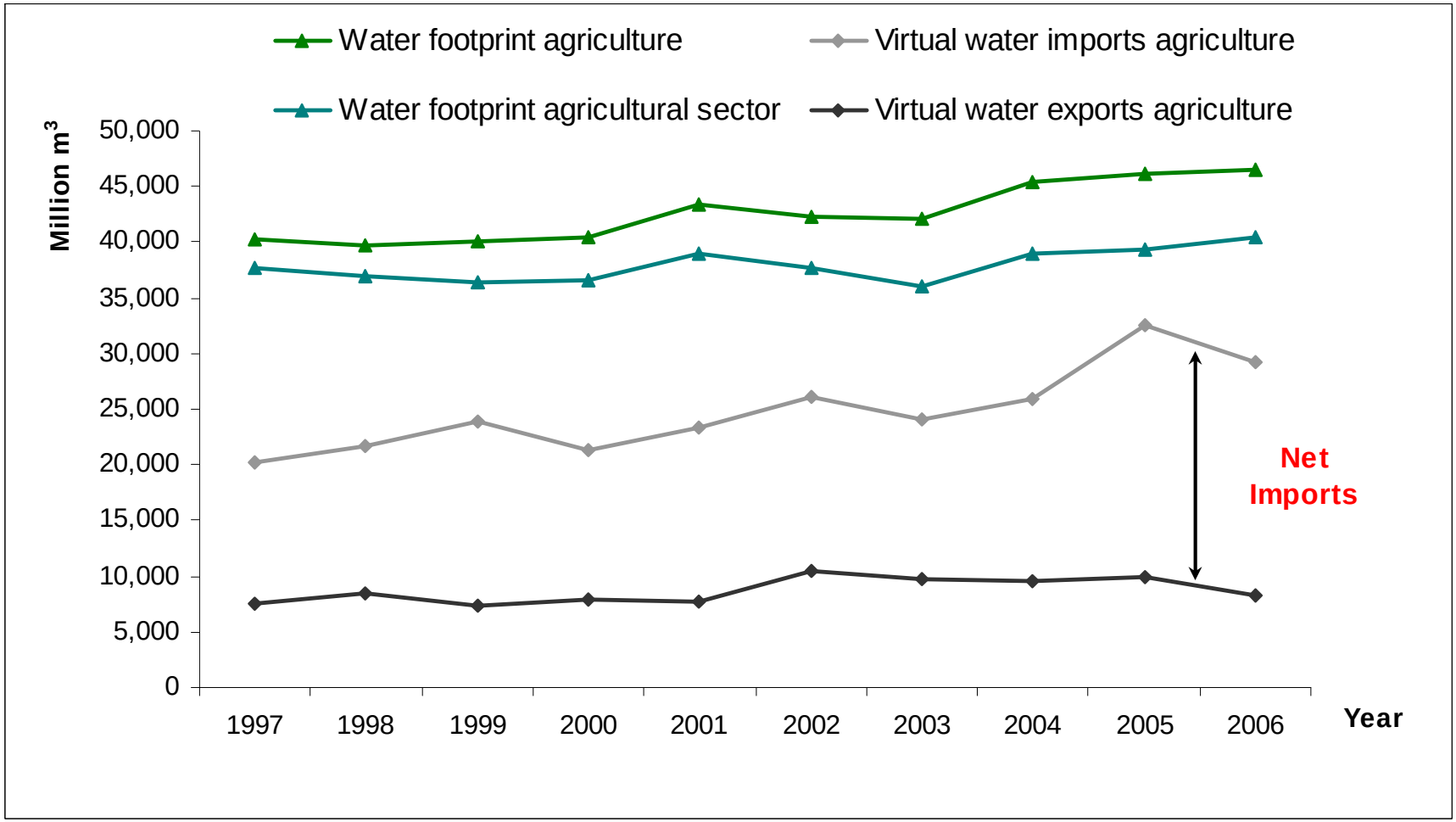
Results

1. Water footprint and virtual water of Spain: hydrologic and economic perspectives
2. Water apparent productivity
3. Economic implications for water allocation: inter-basin and intra-basin transfers
4. Does agricultural footprint depend on water scarcity?
5. Water exchange rates
6. Economic growth and the water footprint

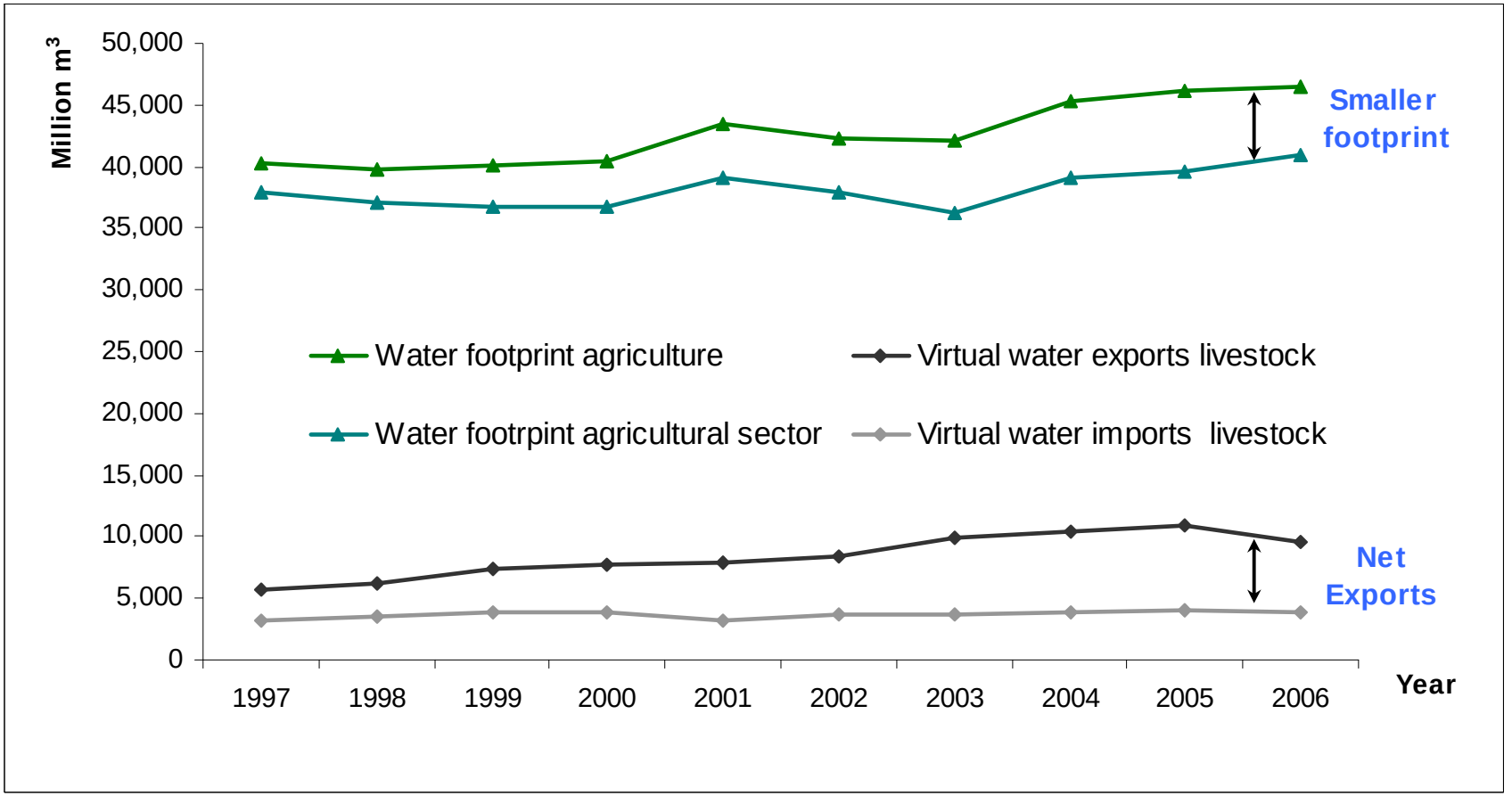
1. Water footprint of Spain (Mm³/yr)



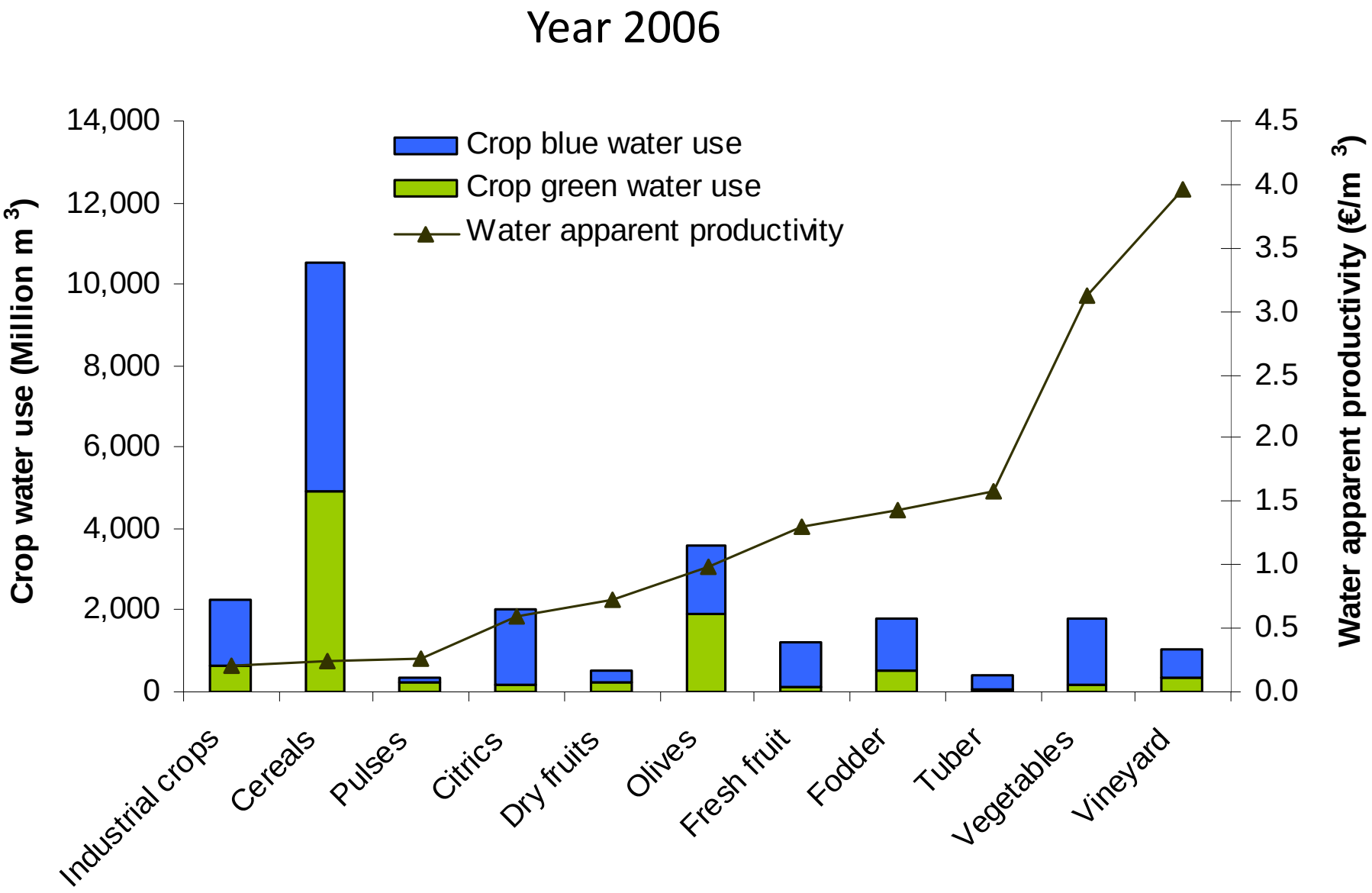
1. WF agriculture and agricultural sector (Mm³/yr)



1. Livestock water footprint (Mm^3/yr)



2. Water apparent productivity in agriculture (€/m³)



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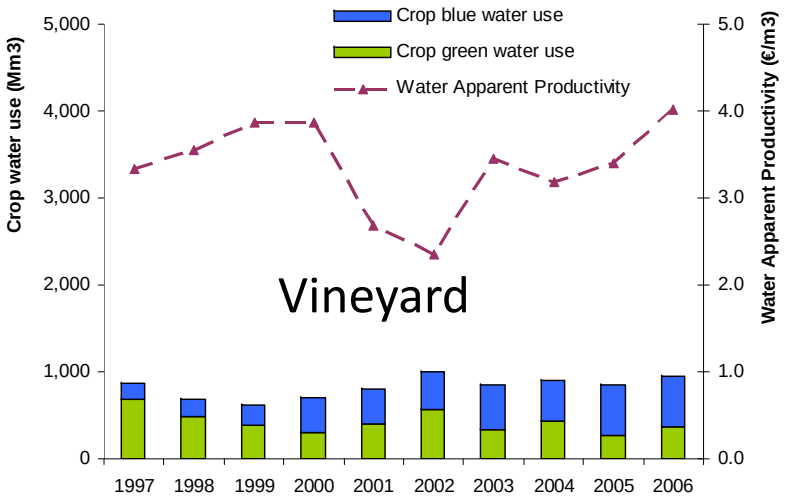
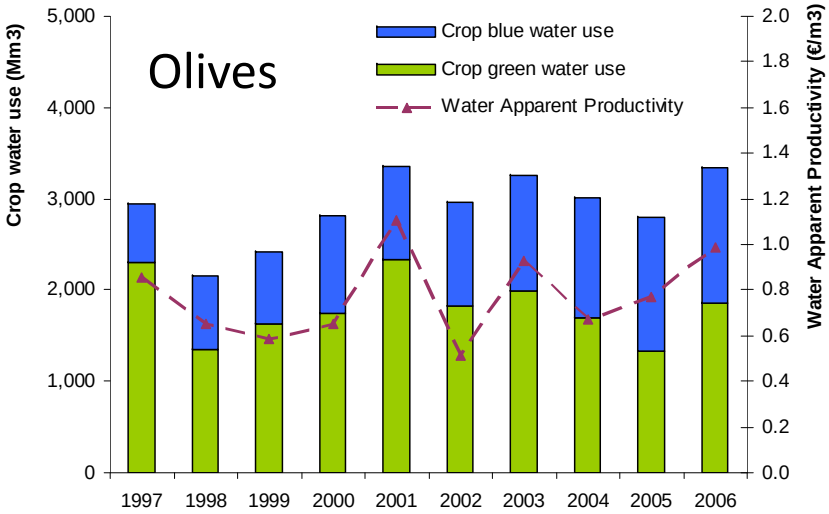
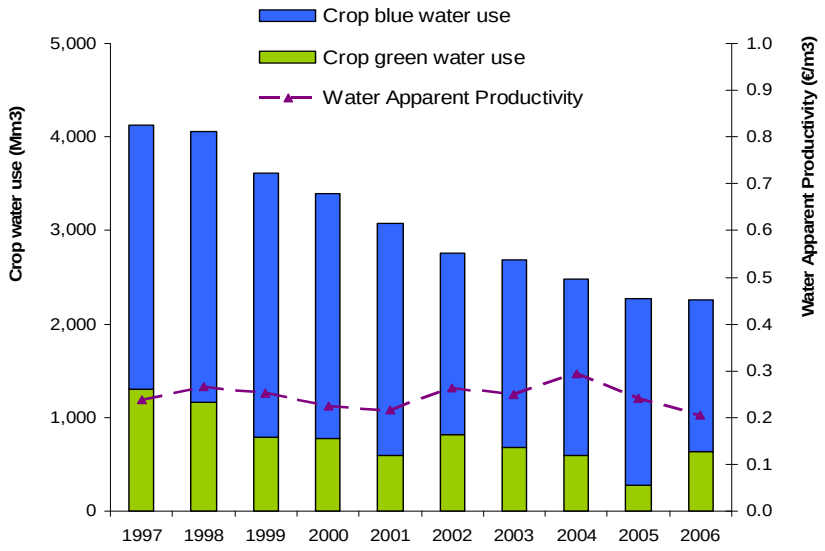




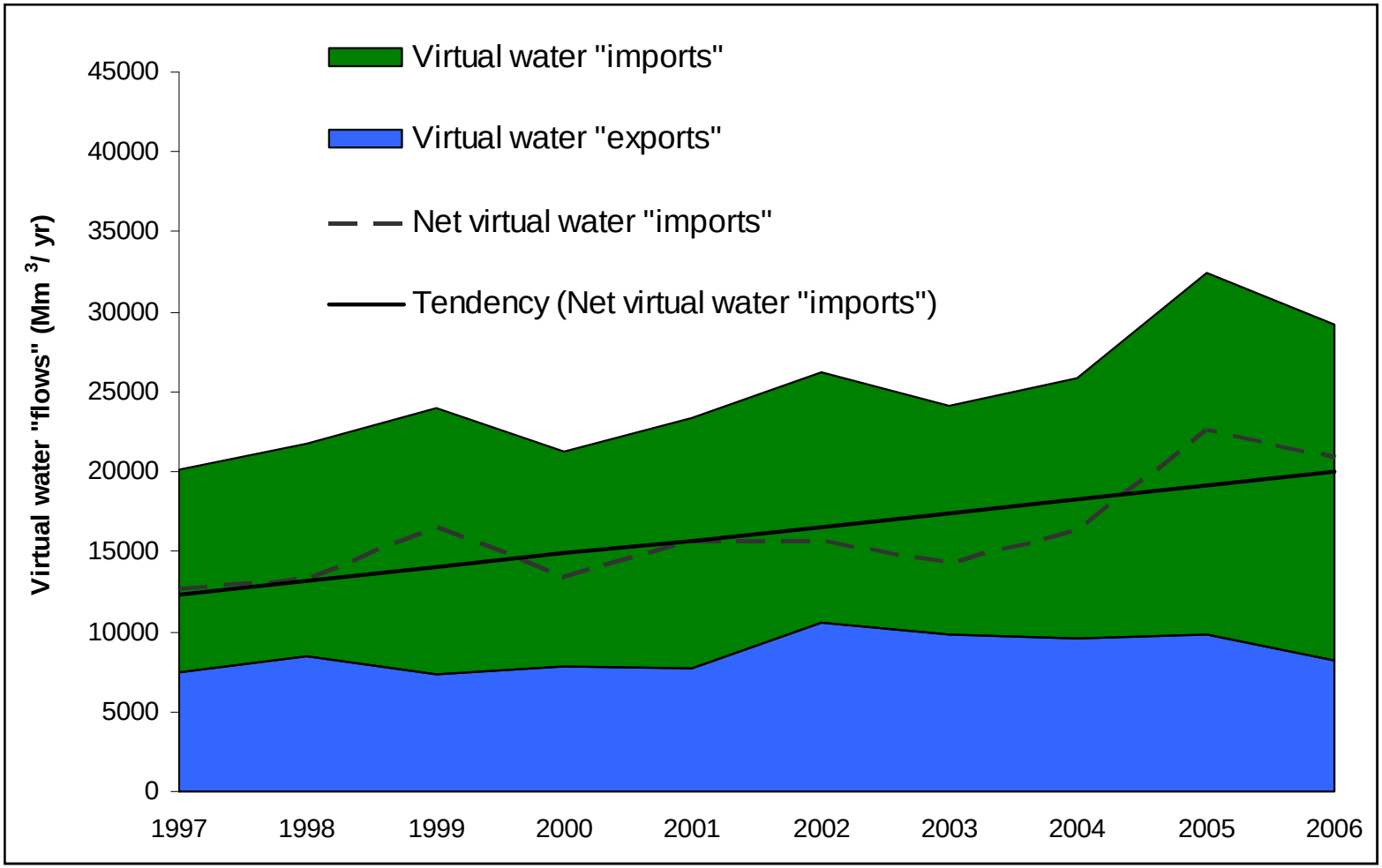
Industrial crops



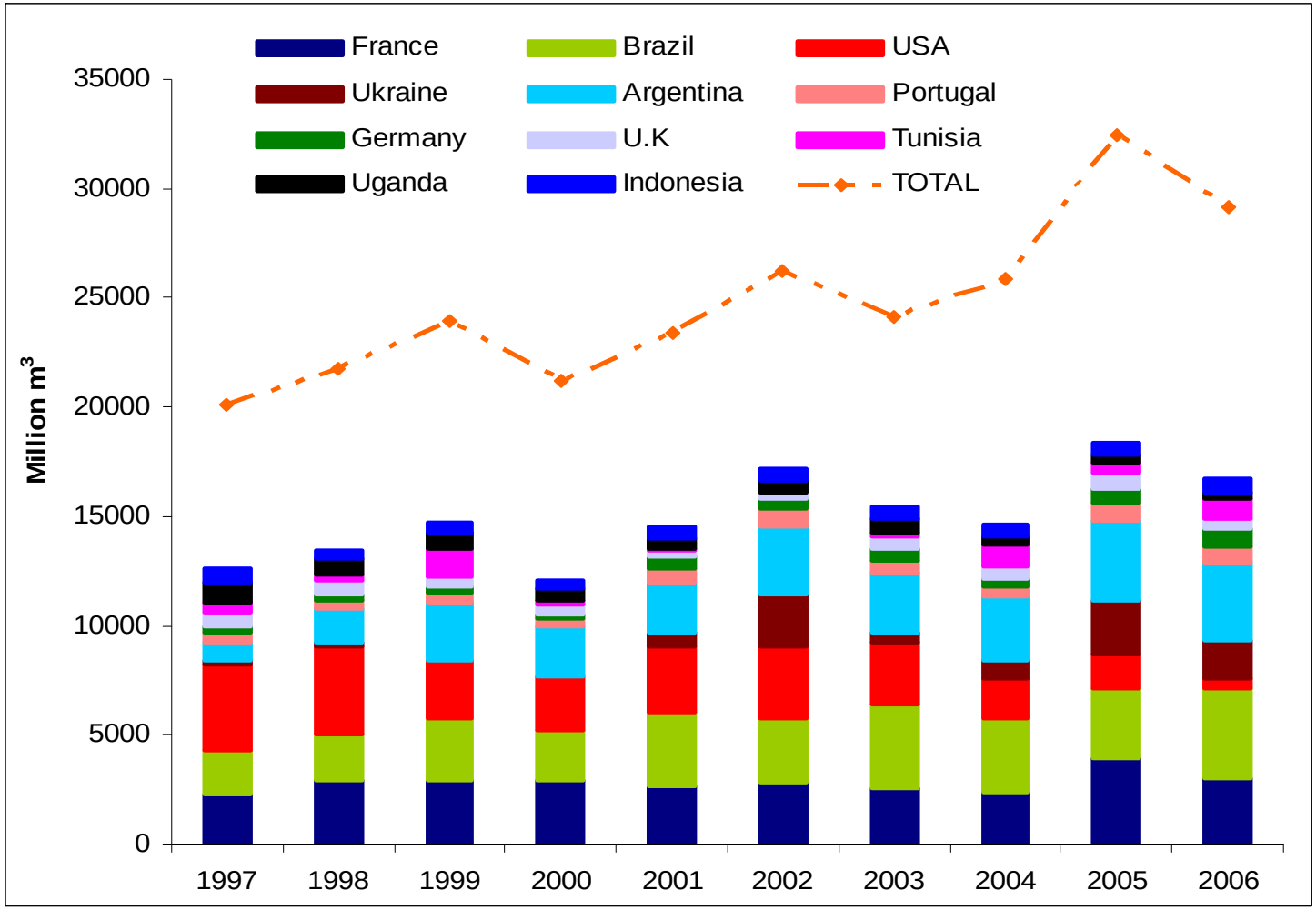
3. Economic scarcity value of blue water use (M€/yr)

Year	Blue water use (%)	Green water use (%)	Total water use (Mm^3)	Rainfall (mm)	Scarcity value blue water (M€)
1997	51,04%	48,96%	27,616	767	925
1998	57,67%	42,33%	26,427	676	895
1999	64,32%	35,68%	23,455	570	1759
2000	59,94%	40,06%	27,046	558	**2515**
2001	59,86%	40,14%	27,743	760	949
2002	57,47%	42,53%	26,675	569	**2283**
2003	59,49%	40,51%	27,761	650	1153
2004	58,84%	41,16%	29,114	713	911
2005	75,67%	24,33%	23,585	452	1956
2006	63,37%	36,63%	25,529	632	**3216**

4- Virtual water 'trade' in agriculture (Mm^3/yr)

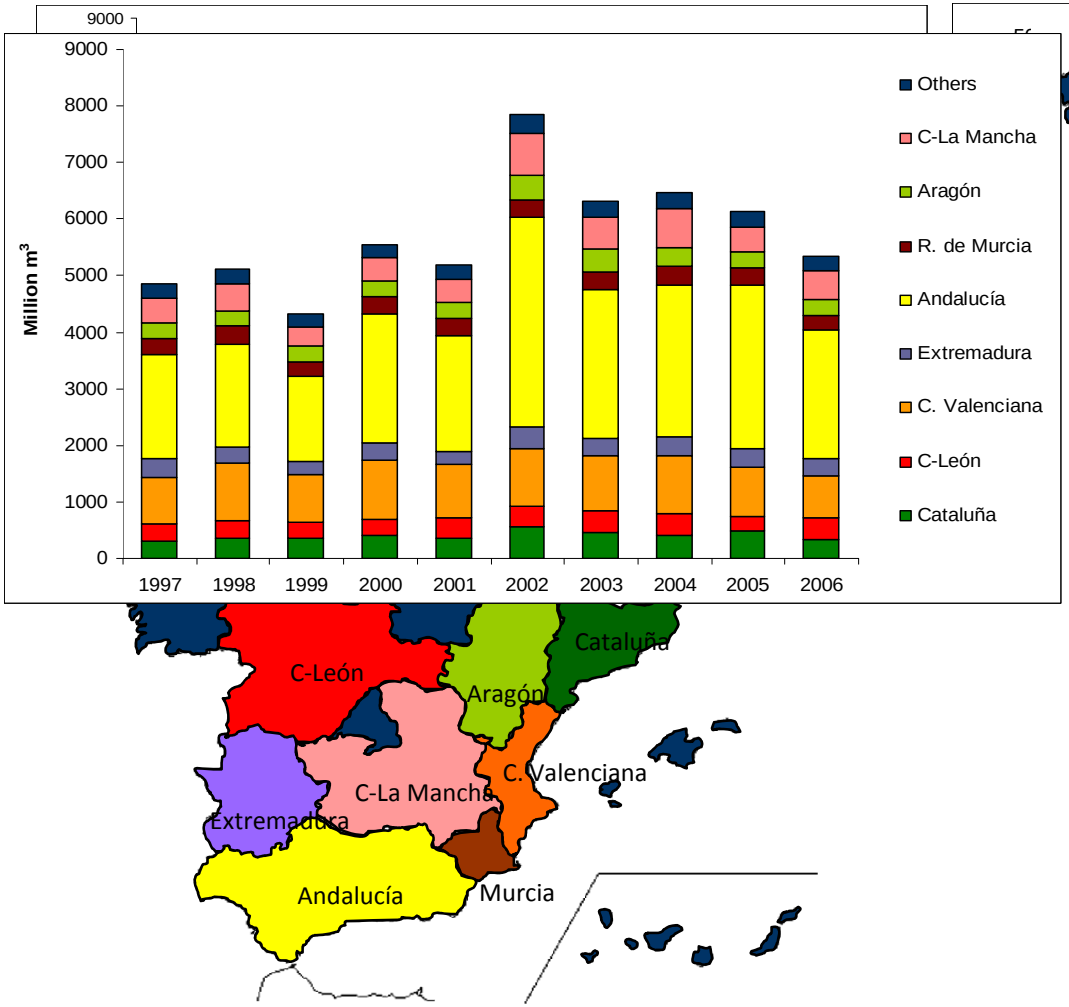


4. Major crop-related virtual water 'imports' (Mm^3/yr)



4. Virtual water ‘exports’ (Mm³/yr and M€/yr)

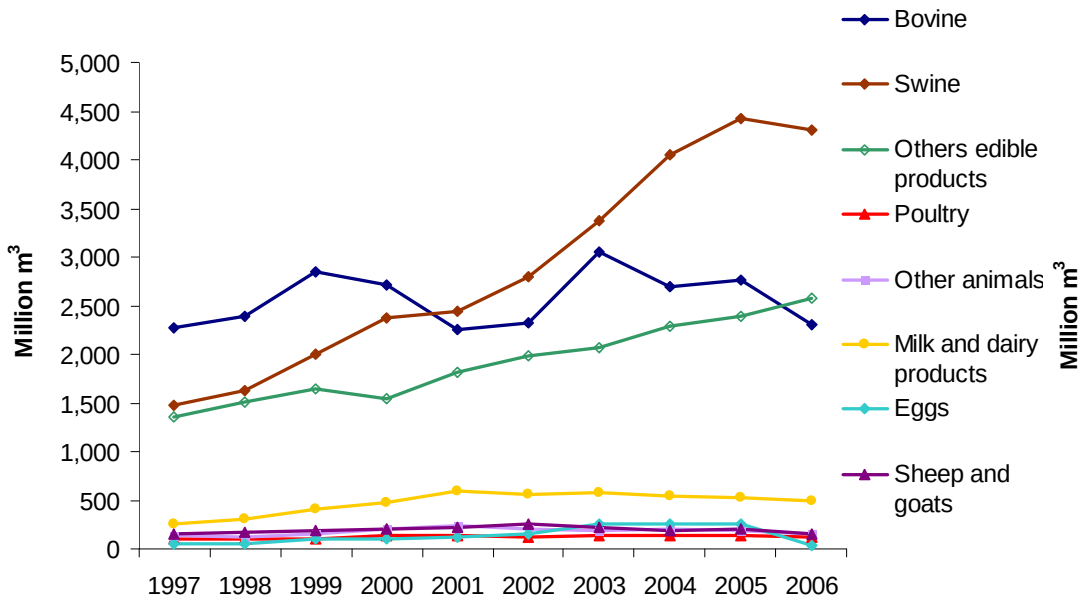
By Autonomous Community



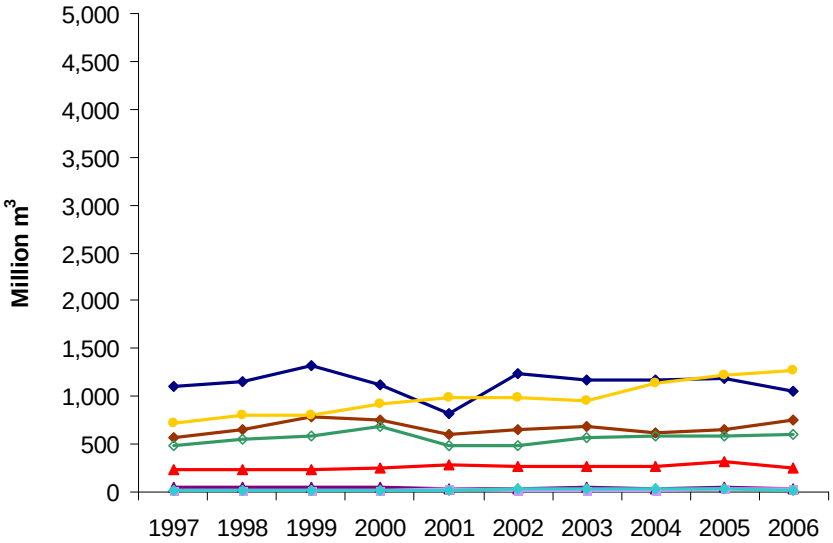
Scarcity value of blue virtual water ‘exports’

4.Livestock virtual water 'trade' (Mm^3/yr)

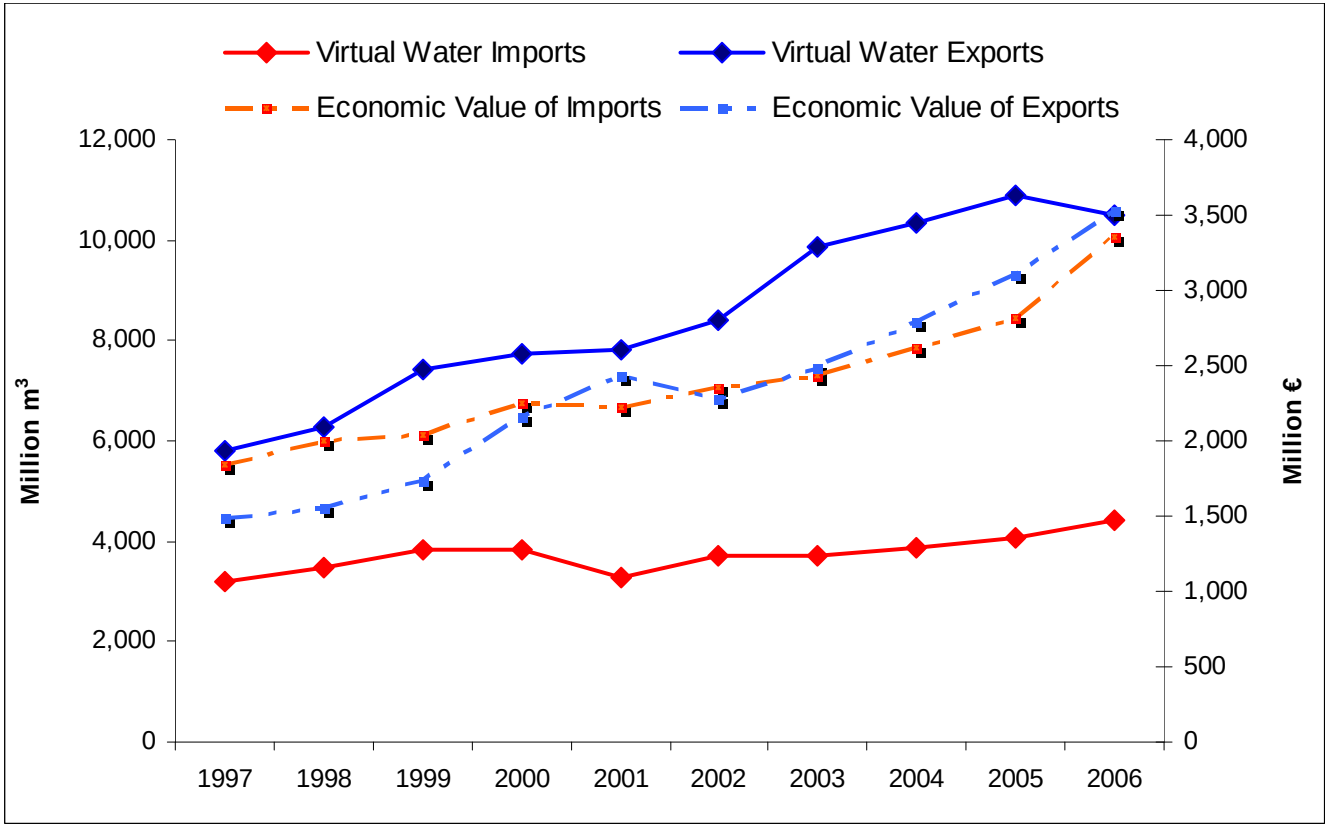
Virtual water 'exports'



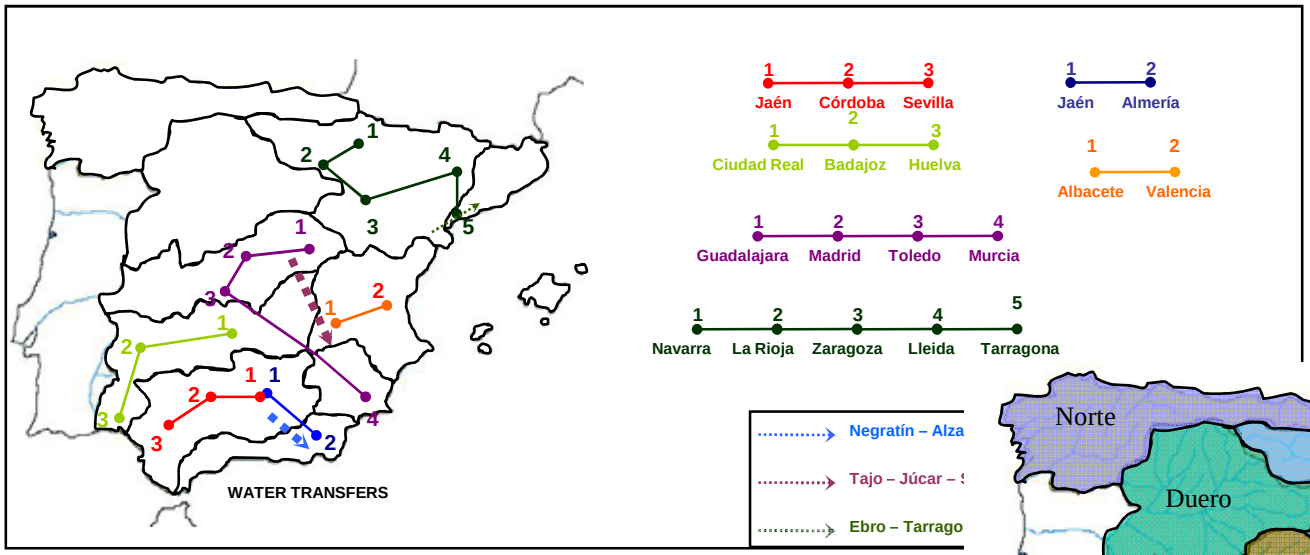
Virtual water 'imports'



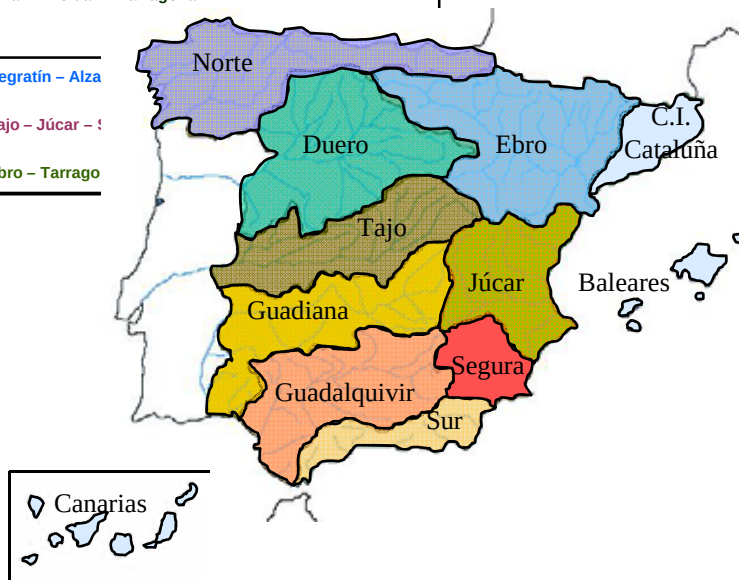
4- Livestock virtual water ‘trade’ and economic value



5. Bringing the analysis to the policy context -- the spatial and time dimensions--

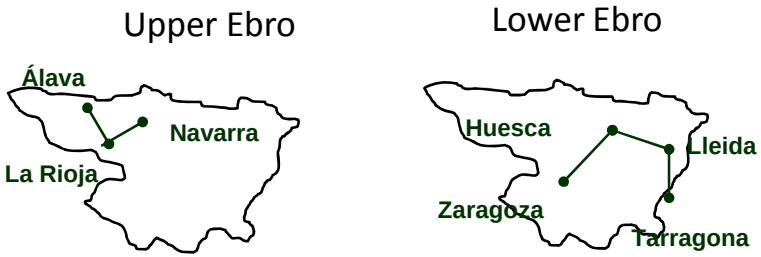


Source: Own elaboration

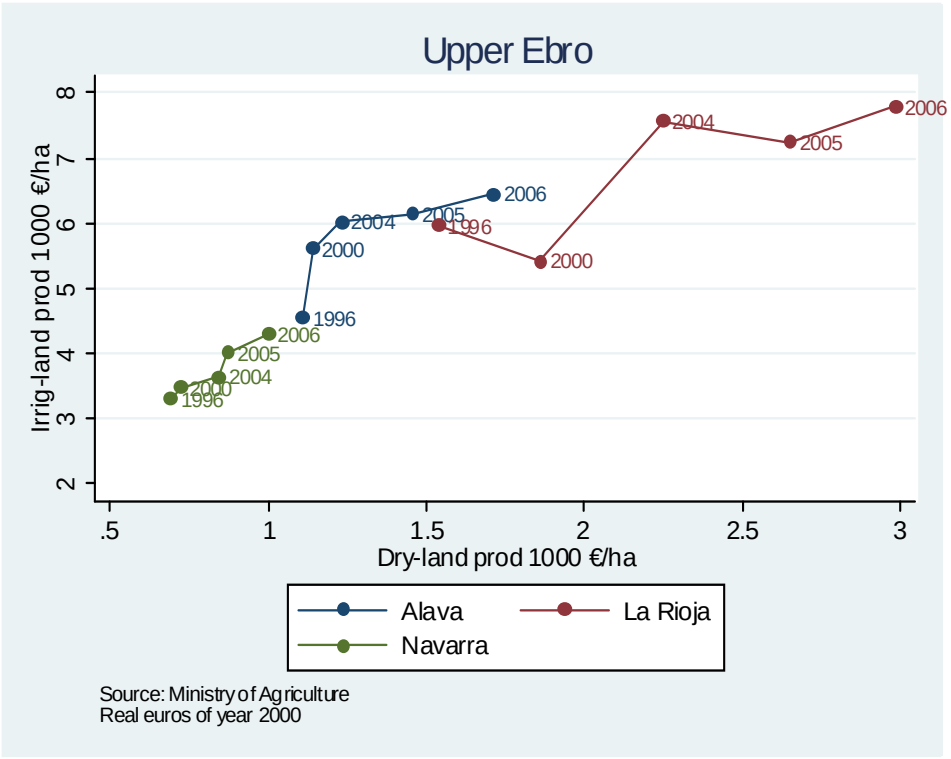


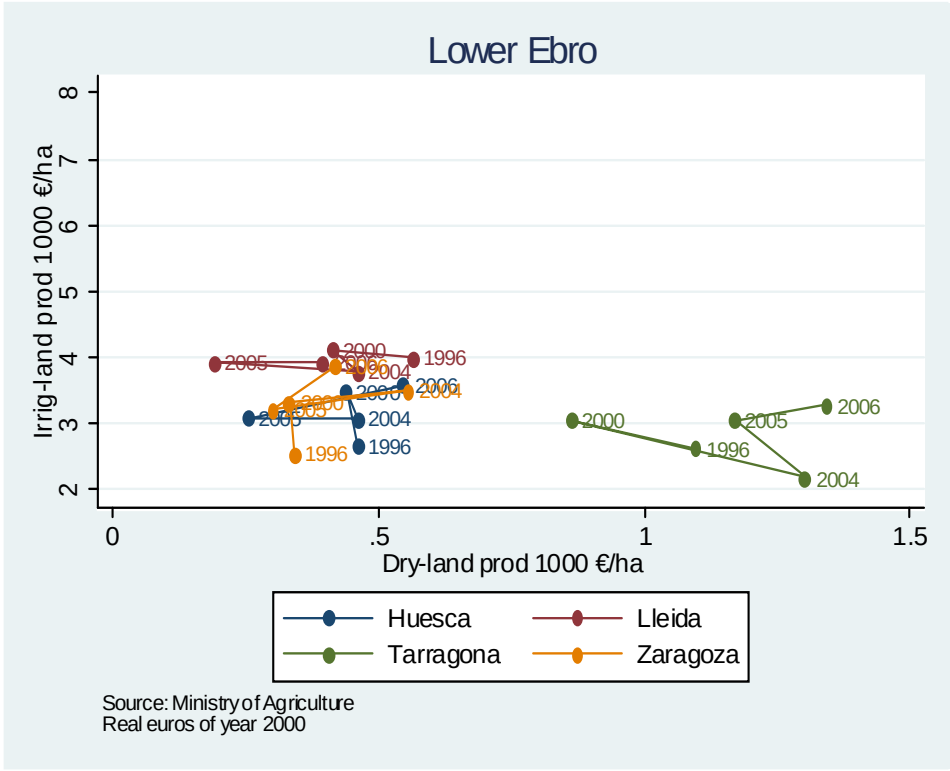
5. The spatial and time dimensions
River basin analysis

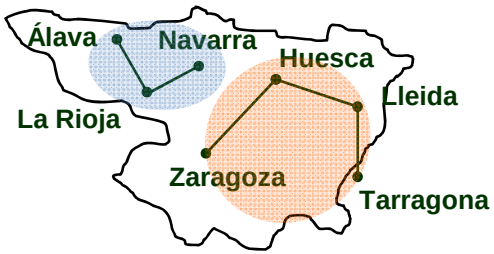
5. The spatial and time dimensions
Case A: Ebro river basin

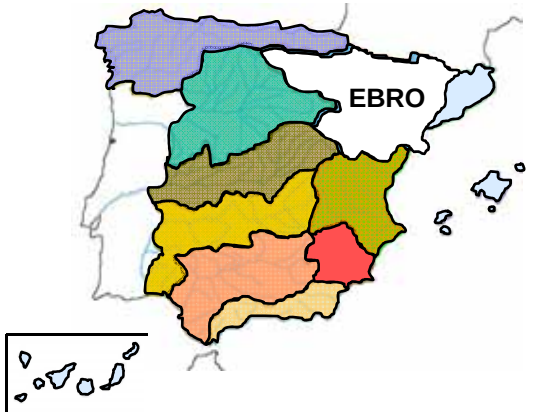


Upper Ebro: Changes in land apparent productivity 1996-2006 (real € of 2000)

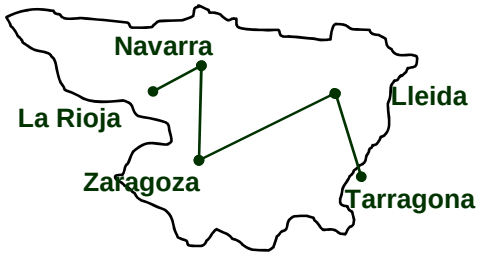




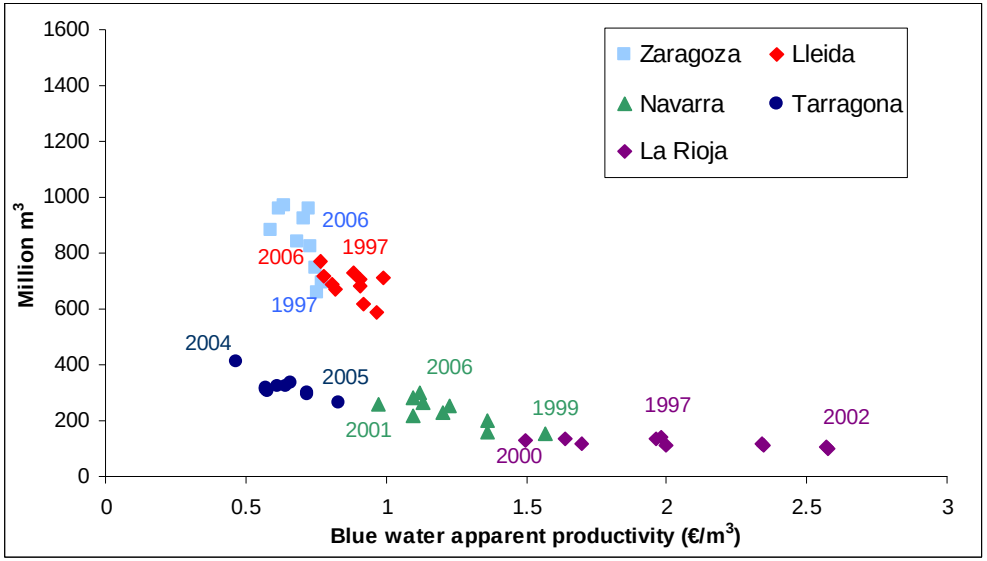




Ebro basin: changes in water apparent productivity

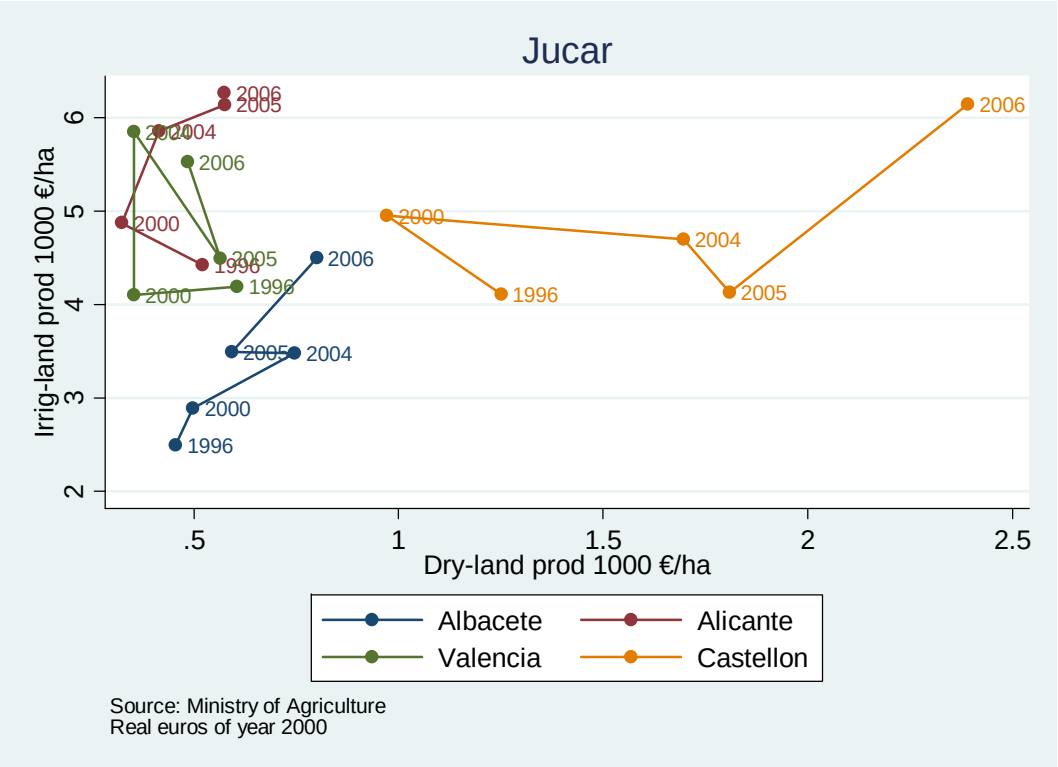


Blue crop water use



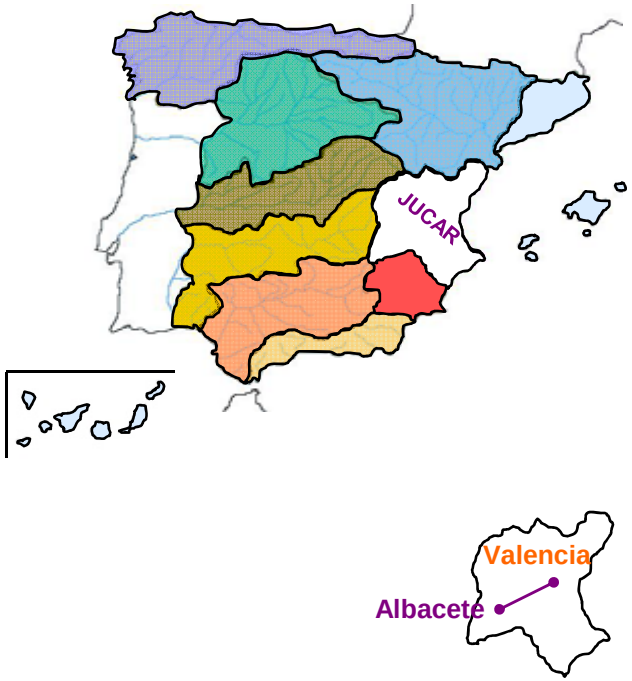
Case B: Júcar river basin

Júcar: Changes in land apparent productivity

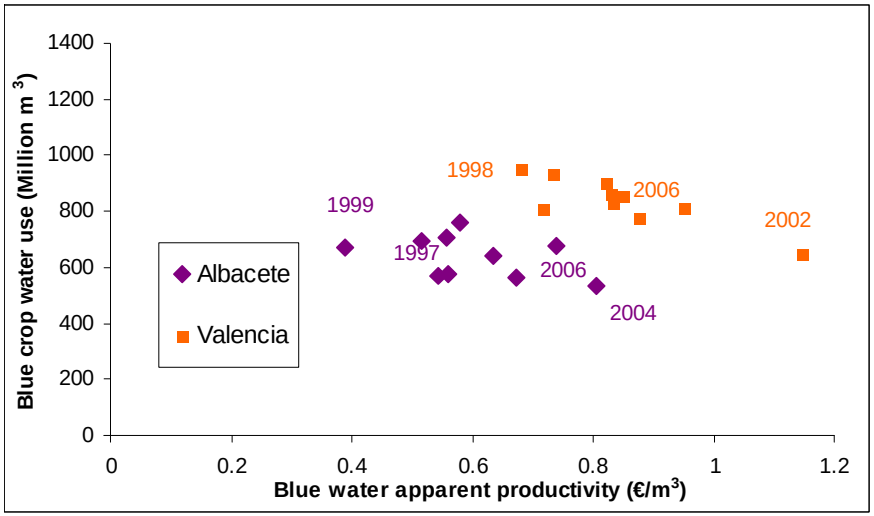


Source: Ministry of Agriculture
Real euros of year 2000

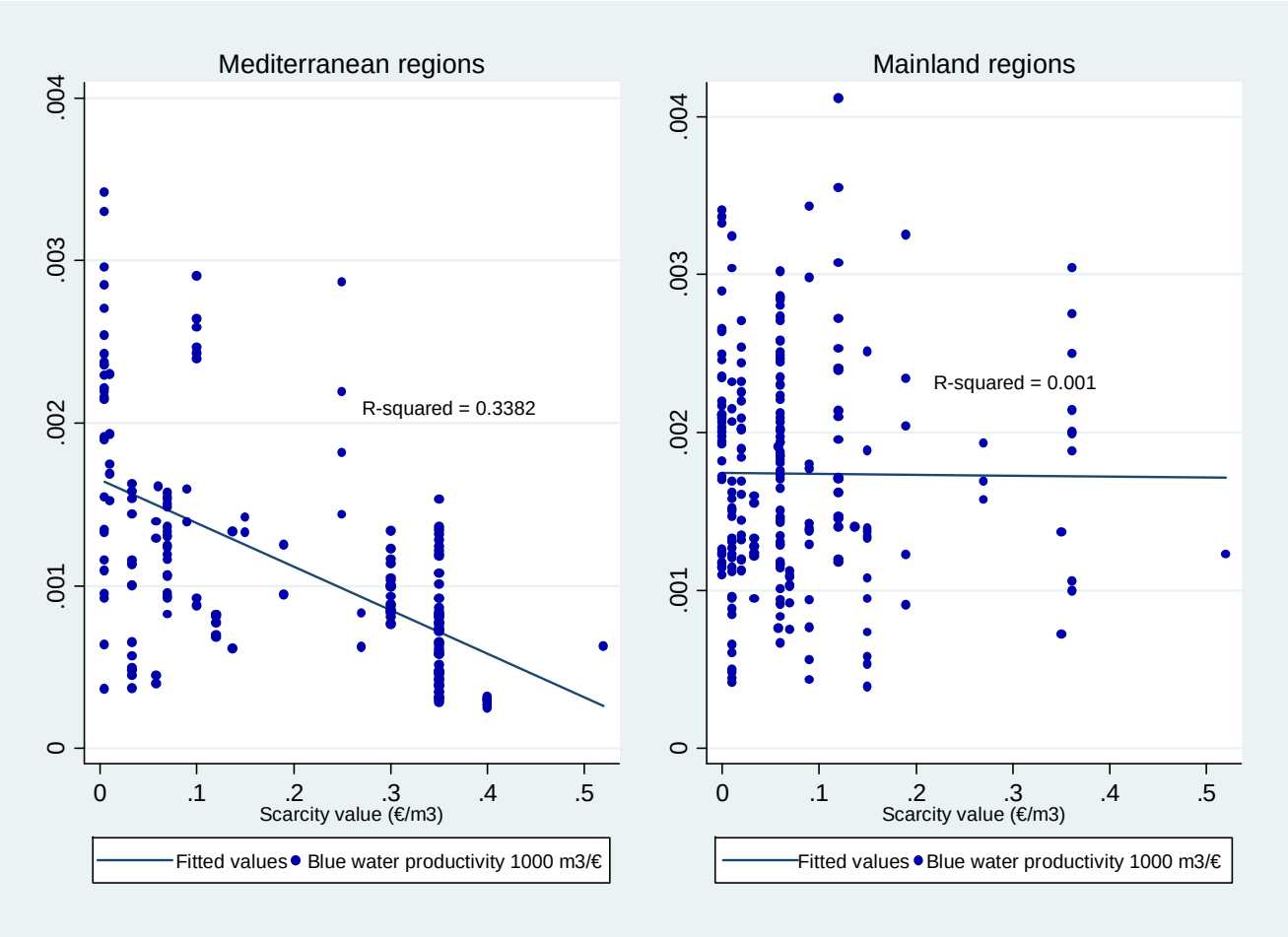
Júcar: changes in water apparent productivity



Blue crop water use



5. Blue water apparent productivity (1000 m3/€) against water scarcity



5. Blue water apparent productivity in light of water scarcity

Mediterranean regions

$$BWP_{it} = \alpha + \beta_1 SV_{it} + \beta_2 GB\%_{it} + \varepsilon_{it}$$

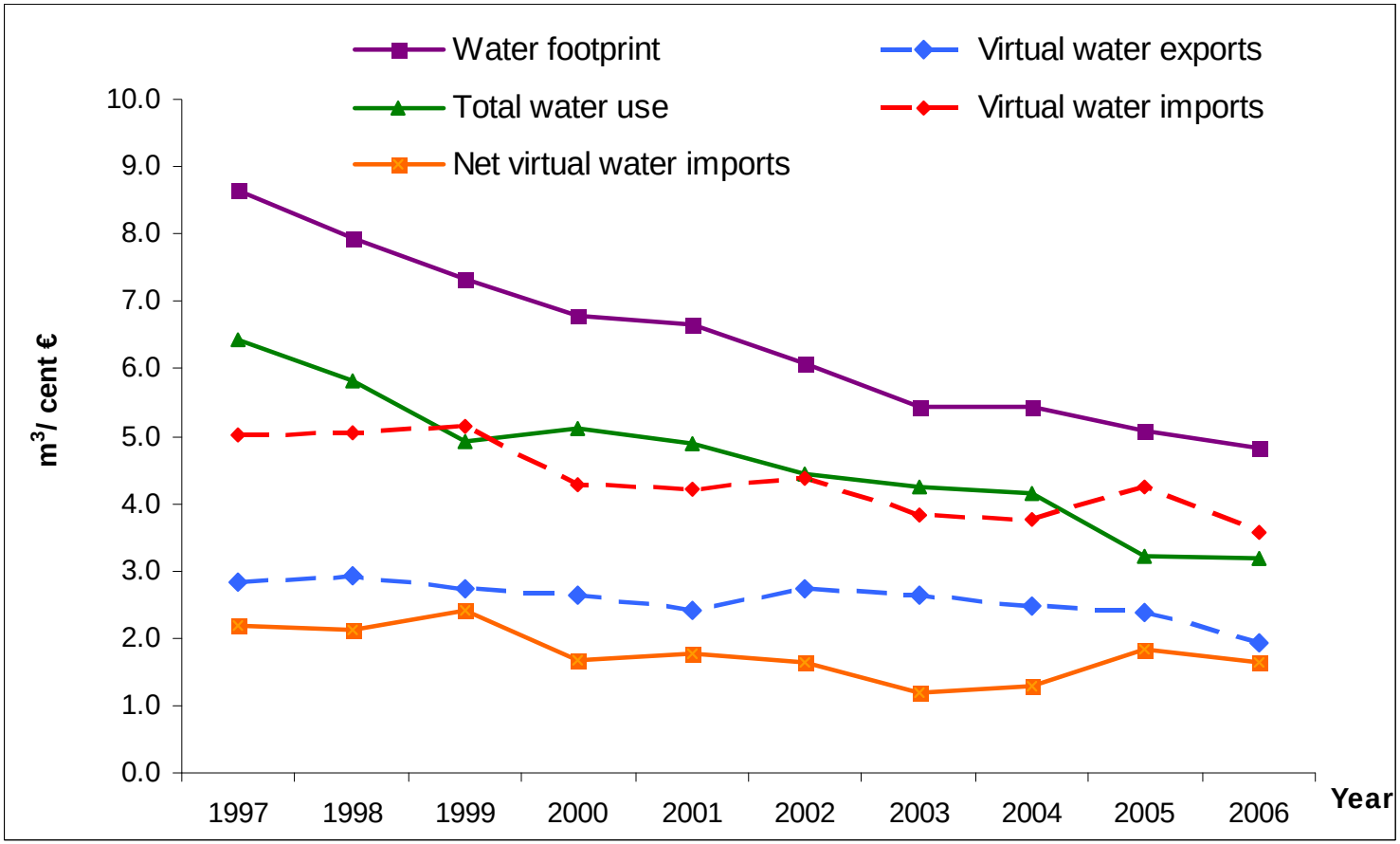
	Coef.	Std. Err.	Elasticity ey/ex
Scarcity Value (β_1)	- 0.0024598**	0.0001644	-0.4348179
Green-blue Water (β_2)	0.000409*	0.0002441	0.0411286
Constant α	0.0015431**	0.0000585	--
Number of obs	190		
Number of groups	19		
Time periods	10		
p<0.05*, p<0.01**			

Inland regions

	Coef.	Std. Err.	Elasticity ey/ex
Scarcity Value (β_1)	-0.0006582*	0.0003287	-0.0289396
Green-blue Water (β_2)	-0.0035889**	0.0004572	-0.3184576
Constant α	0.0022709**	0.0000769	--
Number of obs	220		
Number of groups	22		
Time periods	10		
p<0.05, p<0.01**			

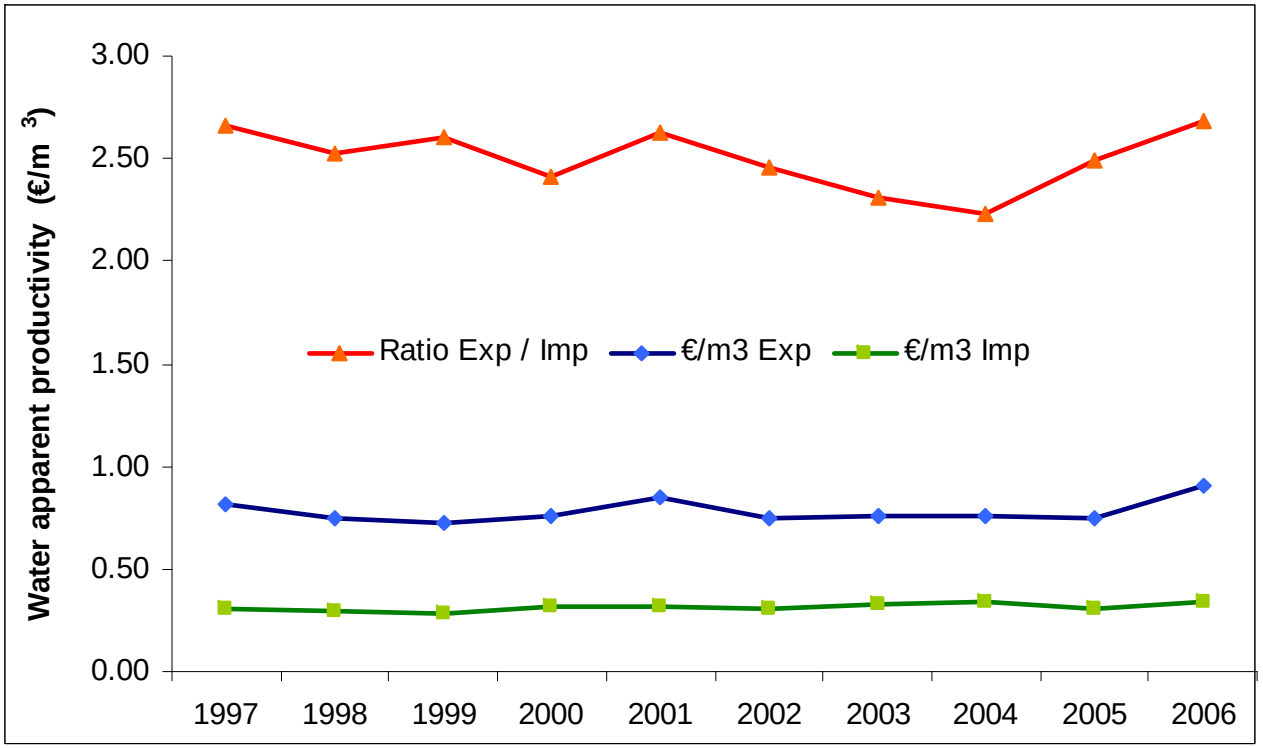
6. Can economic growth be decoupled from water use?

Water footprint and virtual water "trade" per € of Gross Domestic Product



6. Can economic growth be decoupled from water use?

Water 'Exchange Terms'



$$ETerms\_VW_t = \frac{VW^t{}_{\exp}(€/m^3)}{VW^t{}_{imp}(€/m^3)}$$

7. Conclusions

1. VW & WF are valuable indicators for the analysis of water, trade & agricultural policies
2. VW trade contributes to alleviate and mitigate the effects of drought cycles
3. Green vs. Blue water accounting is essential to evaluate VW+WF (proportion varies with years and regions).
4. The ‘water scarcity’ paradigm should be revisited in light of VW trade

Conclusions

5. The Spanish economy is increasingly decoupled from its water footprint, but relies on international trade and thus on virtual water imports/exports
6. Virtual water exports and imports are only slightly dependent on water scarcity
7. Mediterranean provinces are more responsive to water scarcity and, possibly, to market signals
8. Mediterranean regions export more valuable water
9. Water productivity changes within Spain explain regional attitudes towards water markets and questions the upstream-downstream value gradient

Questions for discussion

1. To what extent can VW and WF analyses at basins' and provincial levels contribute to the implementation of the WFD → one single RBMP and marked provincial differences
2. Can inter-basin water transfers be more accurately supported in light of the VW flows? (from water abundant lower value-added productions to water scarce high-value added productions)
3. Can VW and WF analyses throw some light on the environmental effects of the intensive Mediterranean agriculture?
4. Farm trade and agricultural policy are main drivers of the changes seen in Spain in the last 10 years; are they helping